Prepared for

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Latest Operating Experience with Macroporous Resins in the Nuclear Industry

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Colloidal vs. Soluble Activity

- **Colloidal activity accounts for anywhere from 1% to 20% of total activity**
  - *Soluble activity is easily removed by standard Ion Exchange*
- **Colloidal activity removed by the CVCS must remain suspended in the coolant**
  - *It has been speculated that as much as 80% of colloidal mass will settle in the coolant system*
  - *Remaining 20% of mass will account for as much as 80% of the fine particulates that create treatment issues*

Factors Contributing to Colloidal Particulate

- **Longer fuel cycles**
  - *18 to 20 month*
- **Zn injection**
  - *Driving Co, Fe, Ni form intergranular cracks holding source term*
- **Steam generator replacement**
  - *Greater surface area to passivate*
  - *Smaller particulate*
- **Nuclear Plant Power Up-rates**
  - *CILC - Crud induced localized corrosion*
  - *Axel Offset Anomaly or Crud induced power shifts*
  - *Crud burst from upper portion of fuel*

Results of increased Colloidal Activity

- **Water Chemistry Adjustment**
  - *Addressing enrichment such as Boron in deposits*
  - *Increase Li7 for pH control*
- **Pump seal ware**
- **Filter pluggage**
  - *Changing to larger pore filters*
- **Increase in source term**
- **Increase in contamination events**
- **Increase in radwaste**
- **Increase in waste treatment difficulty**

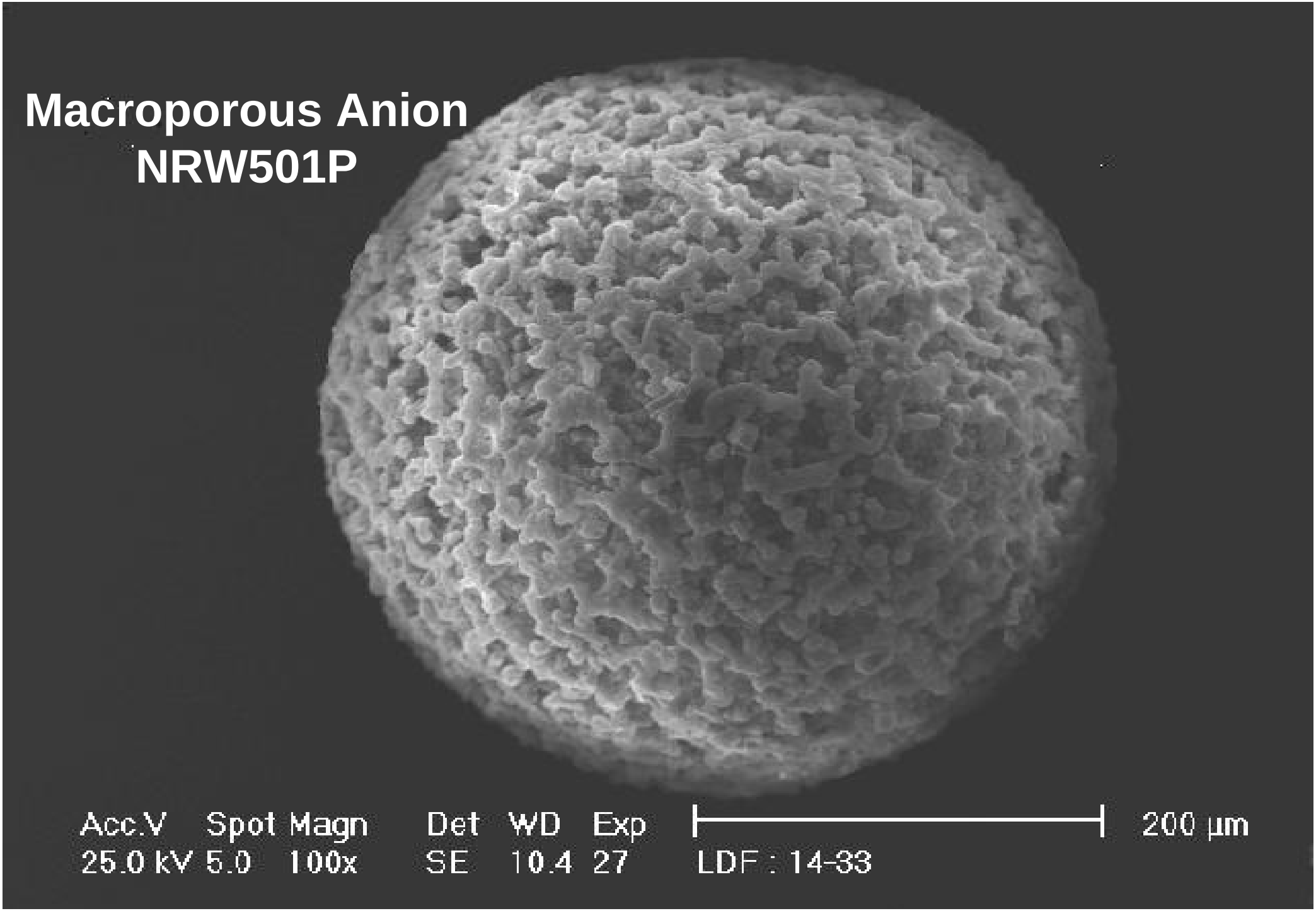
History of Macroporous Resins in the nuclear industry

- ***1970's*** *GE nuclear and Nine Mile Island investigated use of macroporous resins*
- ***2000*** *Insoluble particulates were addressed as a source of activity that needed to be removed*
- ***2002*** *RE Ginna investigated and used the macroporous anion overlay*
- ***2003*** *Independently TVA Sequoyah installed the Macroporous anion and cation layer on a cleanup bed*
- ***2004*** *Robinson, STP and Diablo Canyon used the macroporous resins reporting favorable results*

Current users

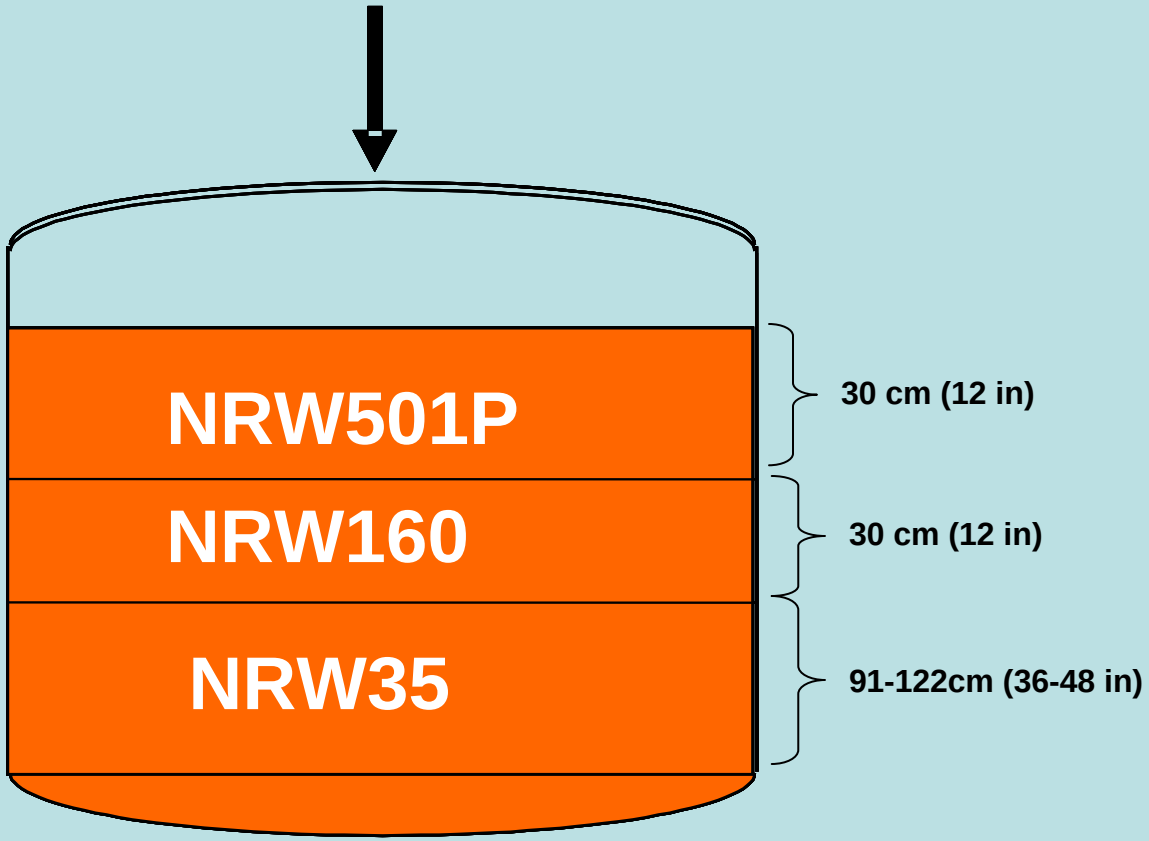
- **Today**
  - **RFO application 25 units have or are using macroporous anions**
    - *22 PWR*
    - *3 BWR*
  - **SFP**
    - *3 units at least installed with macro anion overlay*
  - **CVCS Full Power operation**
    - *6 units are or have used the macroporous overlay*
  - **Radwaste**
    - *5 units have used the anion over lay*

Macroporous Anion
NRW501P



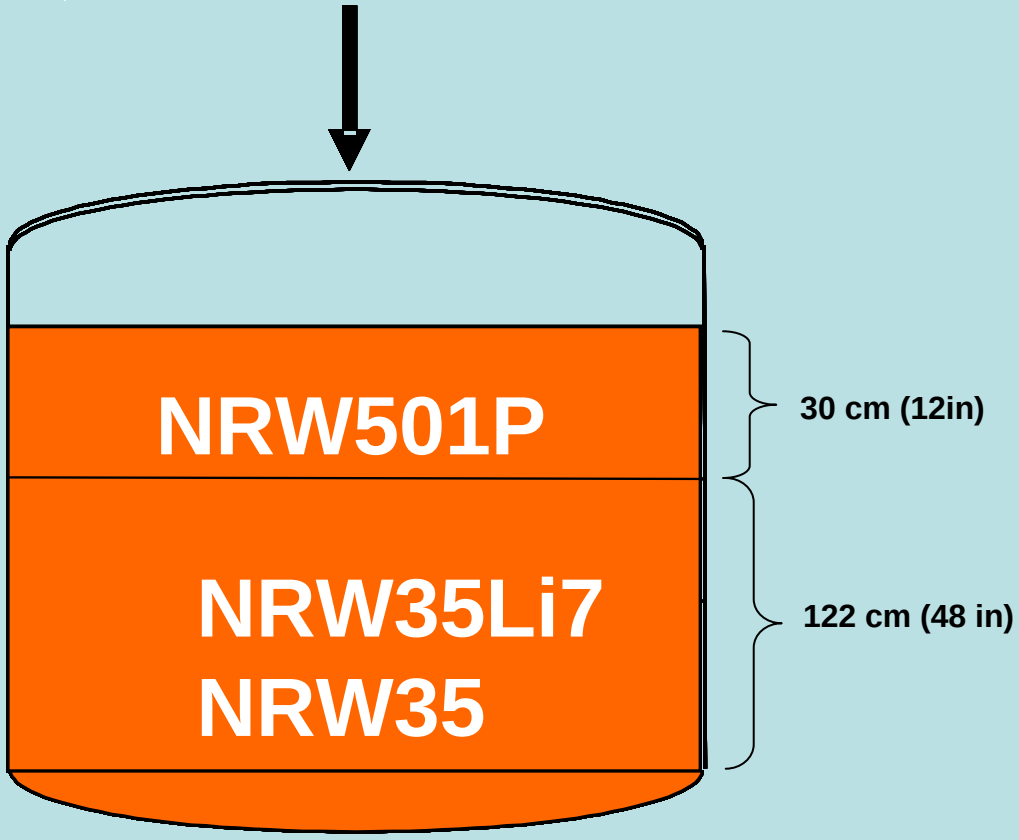
Refueling Outage (RFO) Application

Macroporous Resin Layering in RFO Mixed Bed



SFP & CVCS Application

Macroporous Resin Layering
SFP & CVCS Mixed Bed for Full Power



Mechanism

- **How does the anion work to remove colloids**
  - ***Anionic environment***
    - *Supports stability of metal oxides*
      - *Cobalt 58 associates with nickel ferrite complex*
  - ***Particulate charge***
    - *Minimizes repulsion*
  - ***Pore configuration and sized for entrapment of oxide***
    - *Allows for migration of oxides and small particles into bead*
    - *<.1 µm particles most efficiently removed*
    - *Turbulence at bead surface assists particulate to move past bead boundary layer*

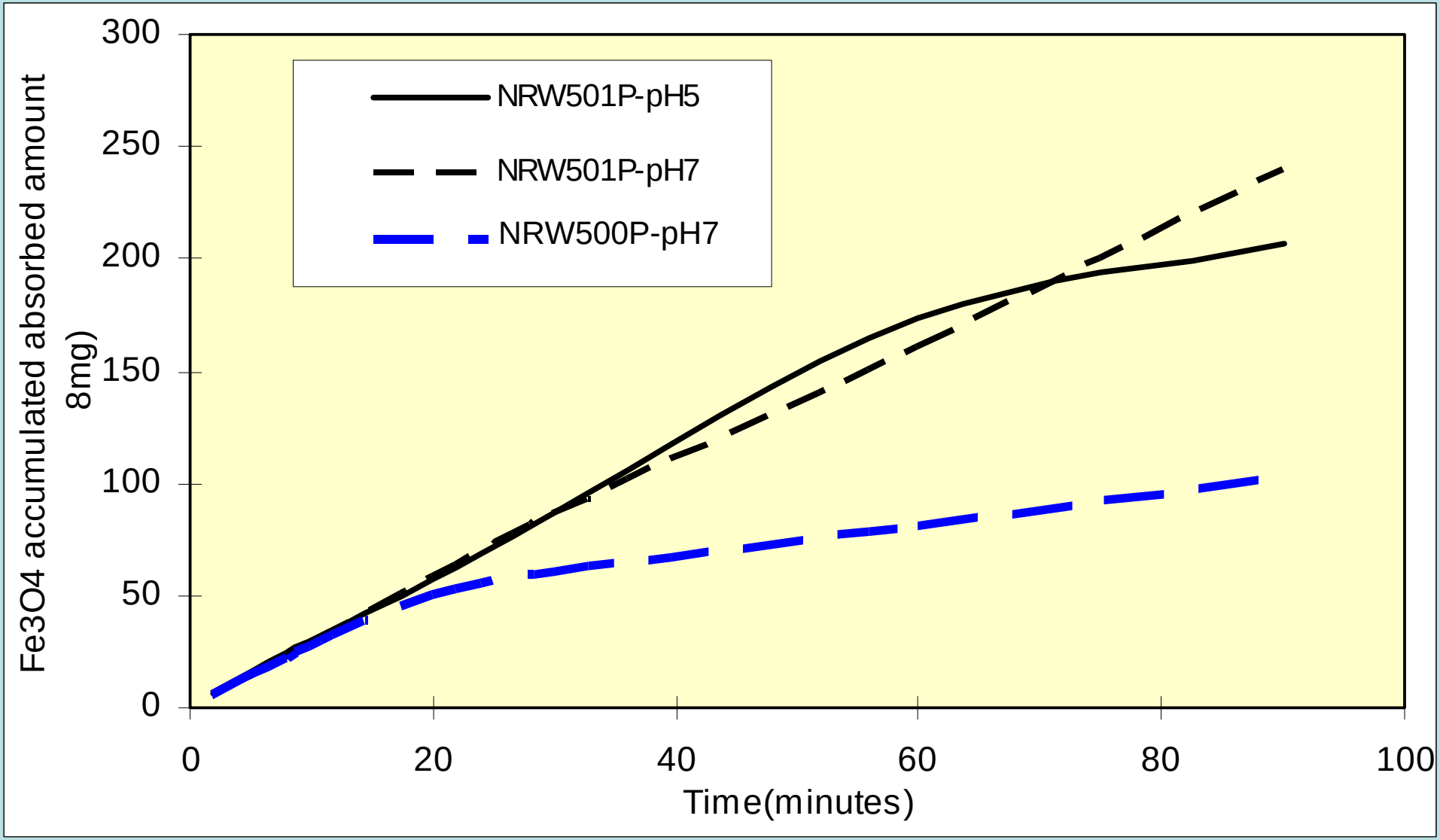
Macroporous NRW501P Pro & Con

- **Advantages**
  - *Appears to remove small suspended particulate (greatest population)*
  - *Impact on larger particles not much different than gel bed*
  - *Flow rate increased for RFO Cleanup OK*
- **Limitations**
  - *Low friability*
  - *Low total capacity*

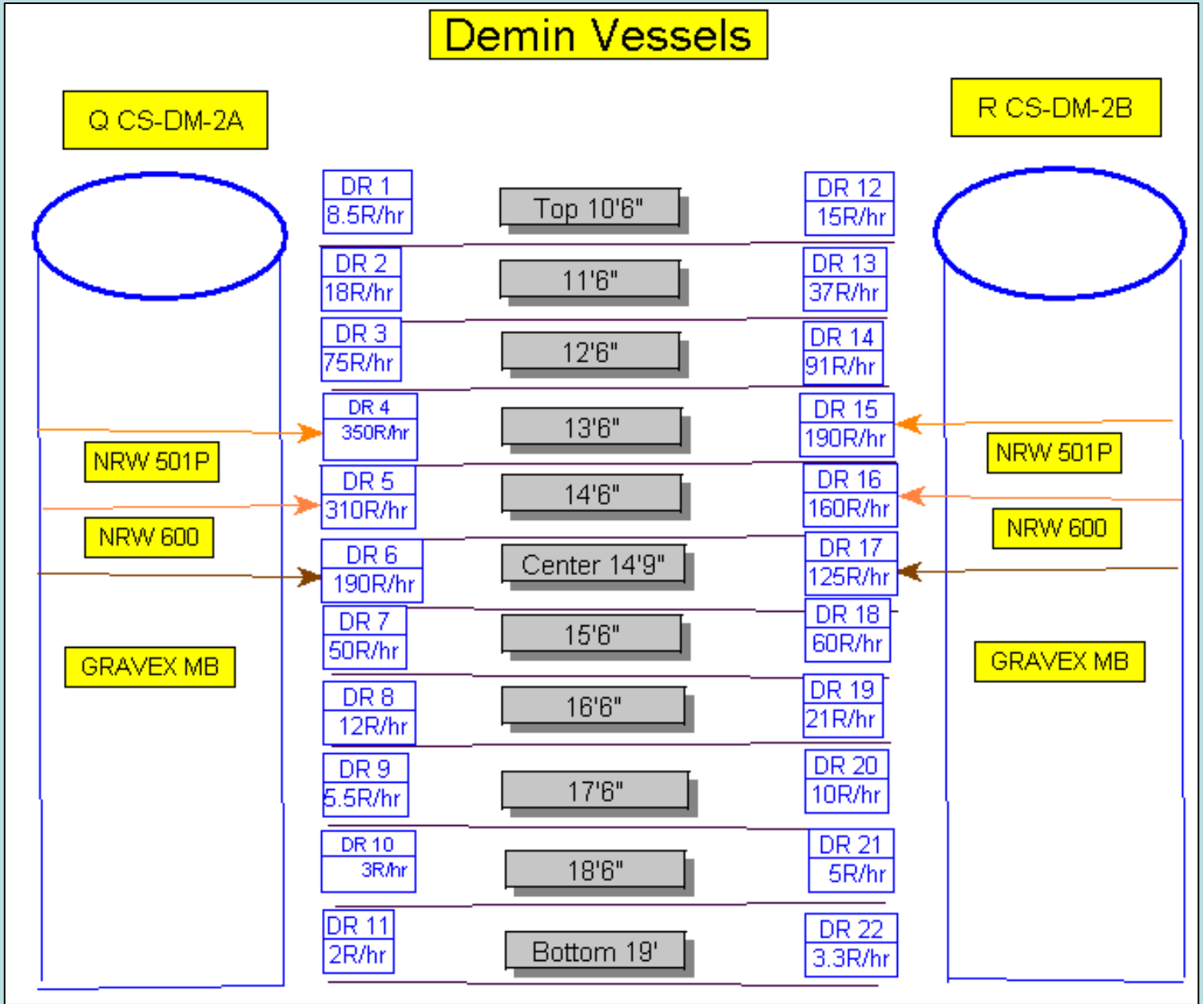
RFO Results

- **Advantages reported during RFO**
  - *Fewer Post filters used with smaller micron size*
  - *Reduction in PCE's*
  - *Greater activity loading on beds*
  - *Lower activity on system surfaces*
  - *Activity in system trends down with multi use*
  - *Reduced difficulty treating radwaste*

pH and Iron Loading

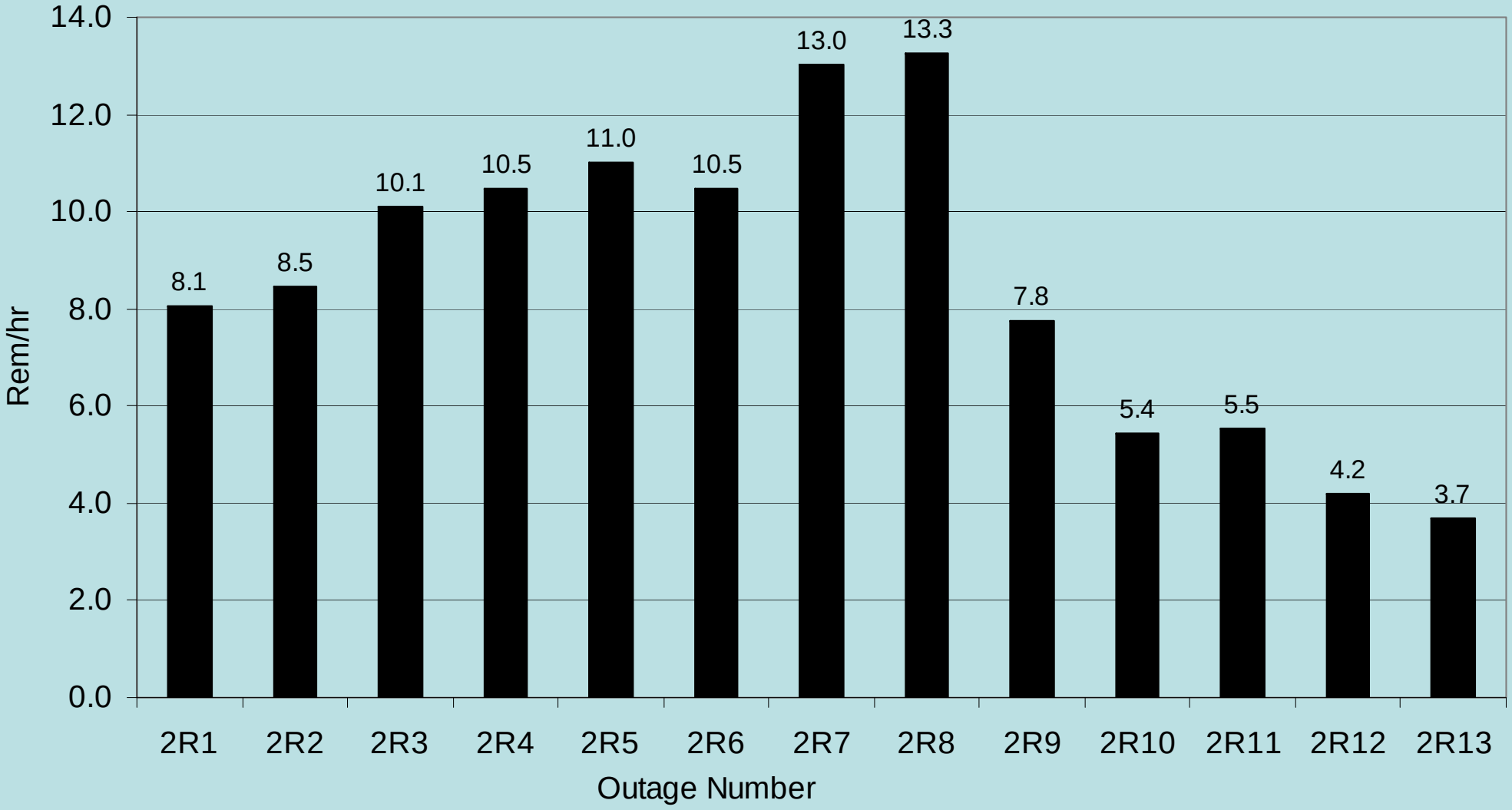


Seabrook Cleanup Demi's

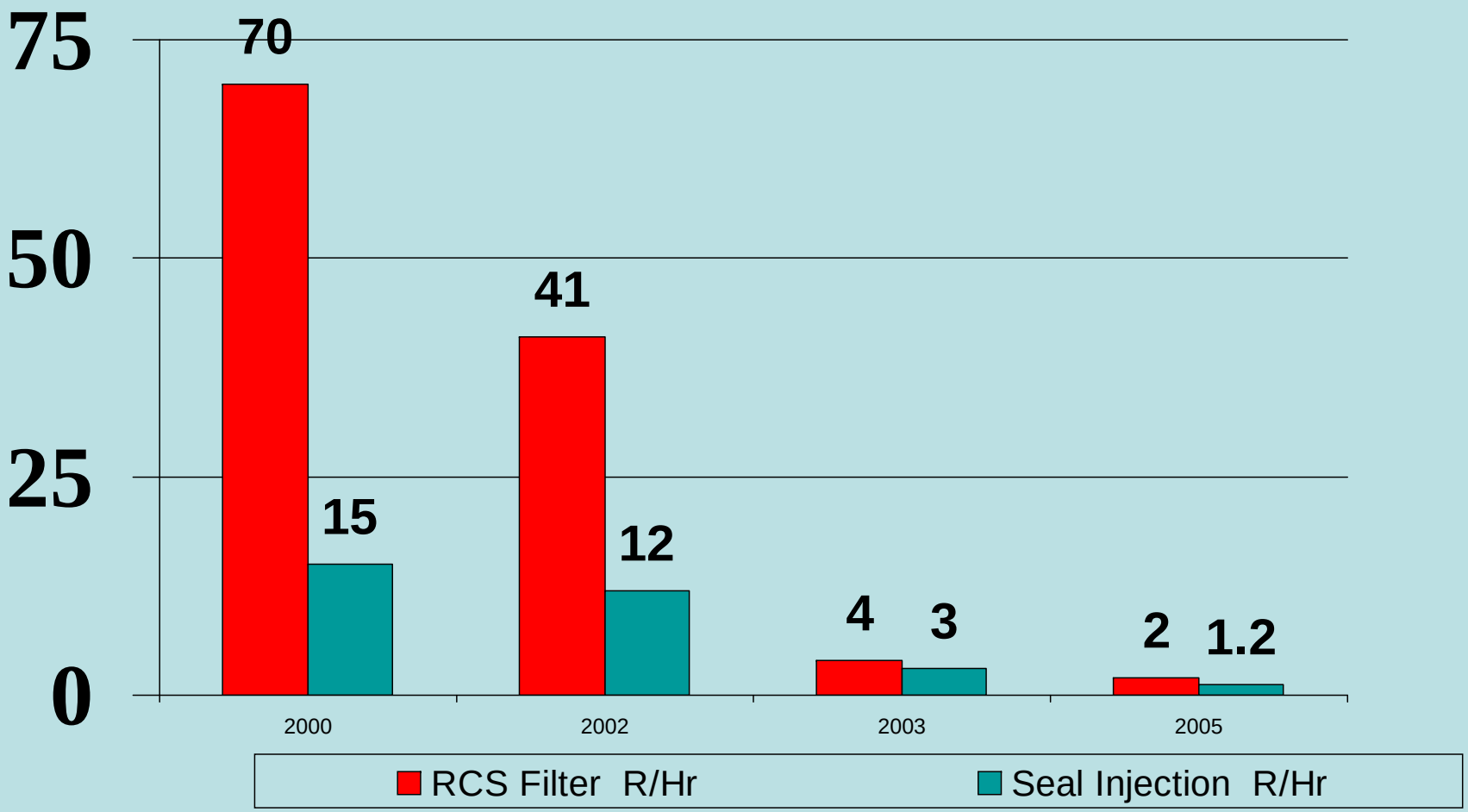


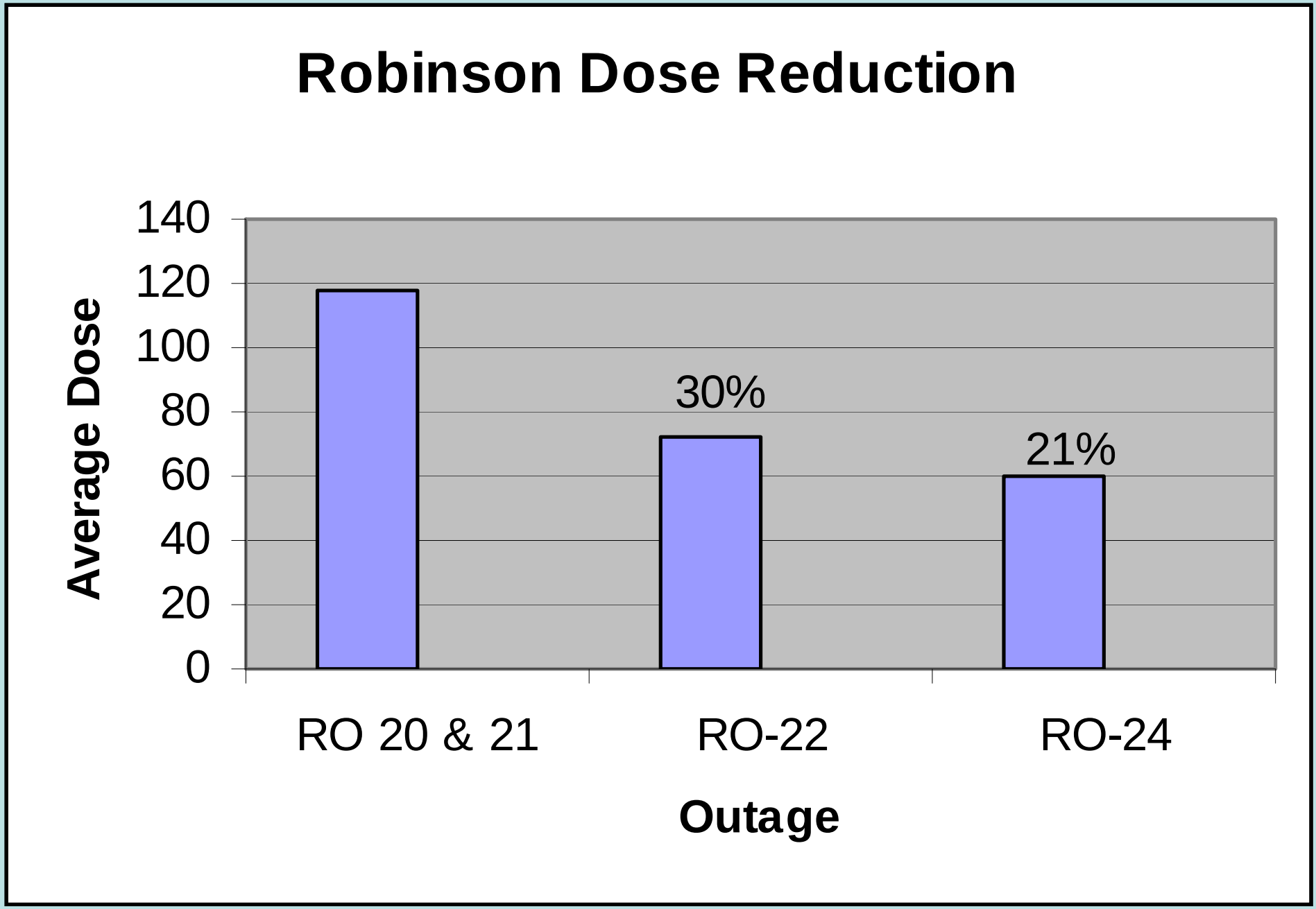
- **Diablo Canyon**
  - *Unit 2 cleanup bed had Macro anion and Macro Cation over mixed resin for outage 2R12 and 2R13*
  - *Overall dose lower for both outages*
  - *SG Manufacturer inspection of primary side and tube sheet reported extremely clean for both outages*
  - *ALARA goal for 2R13 was 100 Rem, achieved was 74 Rem*

Diablo Canyon Historical SG Bowel Dose for Unit 2



RE Ginna


75
50
25
0
70
15
41
12
4
3
2
1.2
2000
2002
2003
2005
RCS Filter R/Hr
Seal Injection R/Hr


Robinson Dose Reduction
Average Dose
140
120
100
80
60
40
20
0
30%
21%
RO 20 & 21
RO-22
RO-24
Outage

Full Power CVCS Overlay

- **Overlay used during full power**
  - *6 plants have used the macroporous anion during full power*
  - ***Objective** is to assist removal of particulate moving during full power*
  - ***Results***
    - *Outages after use have shown lower activity*
    - *Activity passing the CVCS is non detectable*
    - *No operational issues reported with the bed*
    - *Post filters used*
      - *Diablo Canyon reported an increase post filter use*
      - *Sequoyah and Watts Bar use a similar number*
      - *Robinson and Ginna report using only one filter per cycle*

Conclusion

- ***Particulate levels vary*** *from system to system*
- ***Macro Anion*** *appears to* ***reduce activity*** *in system by filtering fine particulate reducing dose, post filter use and contamination events*
- ***Good operational practices*** *contribute to cleaner systems and* ***macroporous resins*** *appear to* ***complement*** *these efforts*
- *Macroporous* ***Anion is durable*** *and able to operate at increased cleanup flow rates with out issue*
- *Use of Macro Anion* ***overlay during full power*** *is possible however an* ***increase in post filter replacement*** *may occur.*
- *Plants using Macroporous resins during cleanup see* ***improved handling of radwaste*** *streams*
- *Macroporous anion used in SFP where fuel is stored dry have* ***reduced decon*** *of storage casks*